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Experimental research of the bovine black albumin spray drying processes

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Abstract. The paper shows the results of the experimental research of the spray drying of the bovine black albumin. The physicochemical properties of the dried bovine black albumin were obtained. The granulometric composition and the particle shape structure of the dried product were obtained for the spray drying using the centrifugal sprayer and the pneumatic sprayer for the various solid content range in the source product and the various drying agent initial temperature. The effect of the spraying method, the drying agent initial temperature and the solid content range in the source product on the dried bovine black albumin particle average size was defined.

1. Introduction

The bovine blood albumins are globular proteins contained in the bovine blood (black albumin, food albumin) and bovine serum (bovine serum albumin, BSA) [1, 2, 3, 4]. The bovine albumins are used for laboratory researches and to produce various medicines, food additives, farm animals and birds' feeds, glues, and for other purposes.

The bovine albumins are manufactured from the source products (such as the concentrated blood, the blood plasma the blood serum) by the various methods of the drying: the freeze-drying [3, 5, 6, 7], the spray drying [3, 5, 7, 8], the spouted bed drying [7], the fluidized bed drying [7] and the vibro fluid bed drying [7].

This paper is focused on the experimental research of the drying of the bovine black albumin from the concentrated blood using the straight-through spray dryer with the centrifugal and pneumatic spaying devices.

2. Experimental research

Figure 1 shows the simplified scheme of the experimental test-stand. The experimental test-stand consists of the drying chamber *1*, the air heater *2*, the water tank *3*, the source product tank *4*, the cyclone separator *5*, the dried product tank *6*, the blowers *7* and 8, the filters *9* and *10*, the pump *11*, the gate *12*, the control valves *13* and *14*, the flowmeters *F* and the thermometers *T*. The drying chamber *1* is equipped with the pneumatic vibrators to prevent the drying product sticking during the transient working modes. The drying chamber *1* has the shell electric heating system and the thermal insulation to prevent the drying chamber cooling due to contact with the workshop air. The centrifugal sprayer or the pneumatic sprayer are used as a dryer spraying device. The simplified scheme of the test-stand does

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not show the centrifugal sprayer bearings cooling system, the control system of the pneumatic vibrators and the system of the drying chamber shell temperature control.

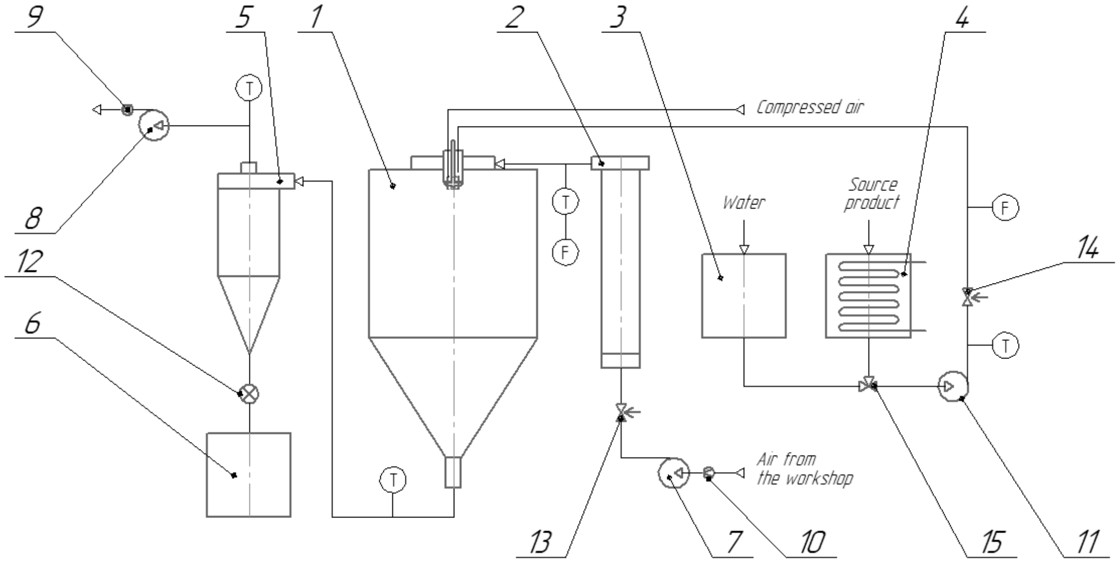

Figure 1. Simplified scheme of the experimental test-stand: *1* – drying chamber, *2* – the air heater, *3* – water tank, *4* – source product tank, *5* – cyclone separator, *6* – dried product tank, *7, 8* – blowers, *9, 10* – filters, *11* – pump, *12* – gate, *13, 14* – control valves, *F* – flowmeters, *T* - thermometers.

The diameter and the height of the cylindrical part of the drying chamber *1* is 1000 mm and 940 mm respectively. The chamber is made of stainless steel. The inner surface of the drying chamber *1* is polished. The drying chamber evaporated water capacity is 10 kg per hour.

The pump *11* feeds the drying chamber *1* by the source product from the source product tank *4*. The source product rate is controlled by the flowmeter *F* and regulated by the control valve *14*. The source product temperature is controlled by the thermometer and regulated using the coil heat exchanger of the source product tank *4*. The source product from the feed line enters to the spaying device (centrifugal disk sprayer or pneumatic nozzle) at top of the drying chamber *1* and forms the spray pattern.

In the case of using the centrifugal sprayer, the spray pattern is formed by rotation of the centrifugal disk with the range of the ration velocity 0-360 rpm. The diameter of the centrifugal disk is 120 mm. In the case of using the pneumatic sprayer, the spray pattern is formed by the source product flow in the spiral channels of the nozzle and by the pressure of spraying compressed air. The pressure of the spraying compressed air is 4 bar.

In our research, we used the heated air as the drying agent. The blower *7* takes the air from the workshop and feed it to the air heater *2*. The air rate is regulated by the control valve *13*. The drying agent leaves the air heater and enters the base of the source product spray pattern at the top of the drying chamber *1*. The temperature and the rate of the drying agent are controlled by the thermometer *T* and flowmeter *F* respectively. In our research, we used the drying agent with the initial temperature in the range of 180-220 °C.

The source product mixes with the drying agent and moves along the drying chamber *1*. During the drying process, the water from the source product evaporates and mixes with the drying agent. The water evaporation takes place due to drying agent and the sources product solution and particles contact the in the highly turbulent flow. The water mass fraction of the dried product particle on the exit of the drying chamber was about 2.5-5% in our research.

The dried product and the spent drying agent leave the drying chamber and move to the cyclone separation. The temperature of the dried product and the spent drying agent is controlled by thermometer T. In the cyclone separator, the dried product solid particles separate from the spent drying agent due to the centrifugal force and goes to the dried product tank *6* through the gate *12*.

The blower *8* removes the purified spent drying agent from the cyclone separator to the workshop through the filter *9*.

3. Results and discussion

Figure 2 shows the granulometric composition of the dried bovine black albumin obtained from the concentrated blood by the spray drying using centrifugal the disk sprayer for various values of the solid content in the source product and the drying agent initial temperature. The temperature of the dried product on the exit from the drying chamber is 90 °C for all shown cases.

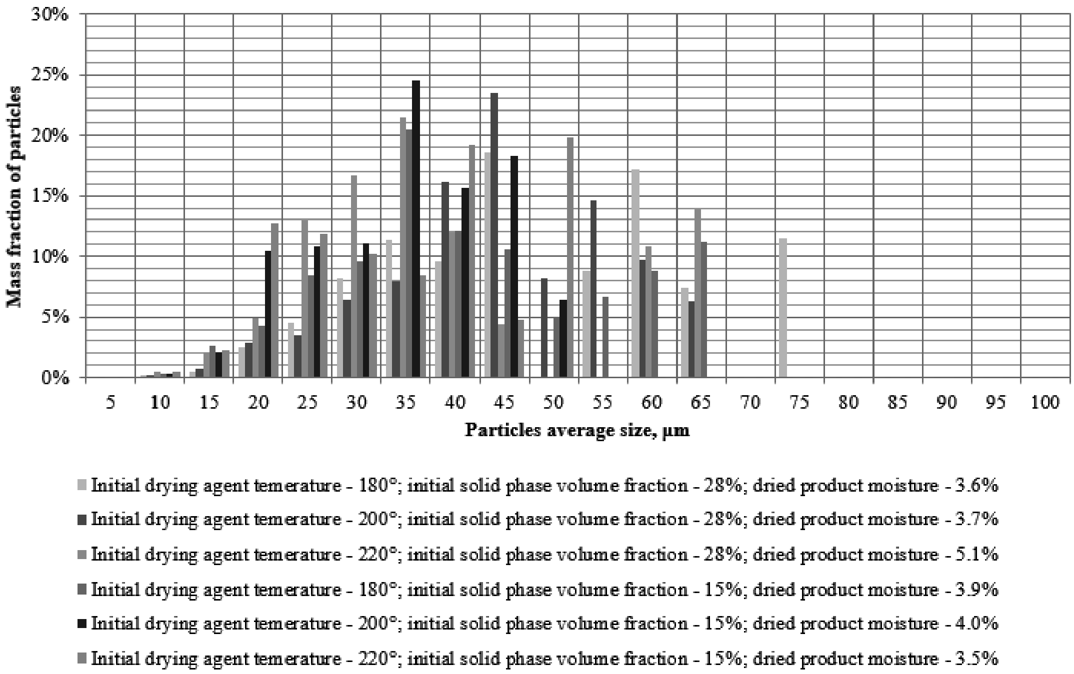

Figure 2. Granulometric composition of the dried product in case of the centrifugal sprayer using.

It was found that the average particle size of the dried bovine black albumin decreases with the growth of the initial drying agent temperature. Average solid phase particle size rises with the solid phase mass fraction in the source product. The average sizes of the solid phase particles for the solid phase mass fraction value in the source product 28 % are 48.8 µm, 45.4 µm and 39.4 µm for the initial drying agent temperature values 180 °C, 200 °C and 220 °C respectively. The average sizes of the solid phase particles for the solid phase mass fraction value in the source product 15 % are 41.7 µm, 34.9 µm and 31.7 µm for the initial drying agent temperature values 180 °C, 200 °C and 220 °C respectively.

Figure 3 shows the granulometric composition of the dried bovine black albumin obtained from the concentrated blood by the spray drying using pneumatic nozzle sprayer for various values of the drying agent initial temperature. The temperature of the dried product on the exit from the drying chamber is 90 °C for all shown cases. The solid phase mass fraction value in the source product for all shown cases is 28 %.

It was found that the average particle size of the dried bovine black albumin significantly decreases with the growth of the initial drying agent temperature using pneumatic nozzle sprayer. The average sizes of the solid phase particles are 60.6 µm, 12 µm and 10.3 µm for the initial drying agent temperature values 180 °C, 200 °C and 220 °C respectively.

The dried product particles obtained using the pneumatic sprayer is bigger than particles obtained using the centrifugal sprayer for the relatively small drying agent initial temperature. The average solid phase particle size in the case of the pneumatic spaying is about 61 µm, and the average solid phase

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particle size in the case of the centrifugal spaying is about 42-49 μm for the initial drying agent temperature 180 °C.

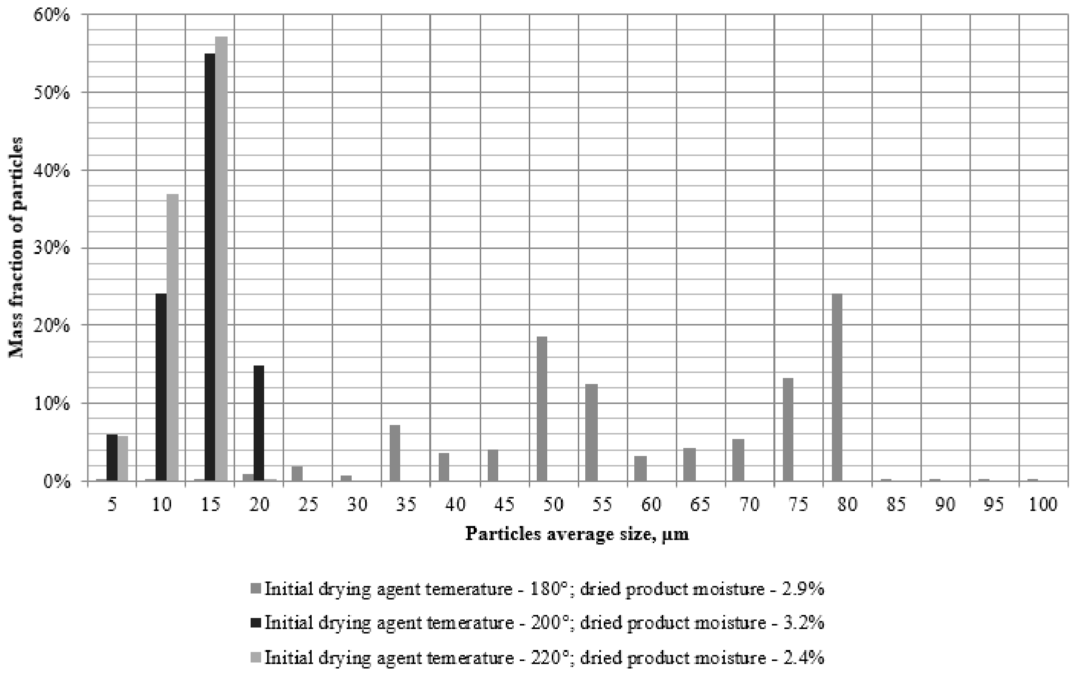

Figure 3. Granulometric composition of the dried product in case of the pneumatic sprayer using.

The dried product particles obtained using the pneumatic sprayer is significantly less than particles obtained using the centrifugal sprayer for the drying agent initial temperature bigger than 200 °C. The average solid phase particle size in the case of the pneumatic spaying is about 10-12 μm, and the average solid phase particle size in the case of the centrifugal spaying is about 31-45 μm for these conditions.

Figures 4 shows the micro photos of the dried albumin particles for the various initial temperatures of the drying agent in the case of the centrifugal spaying. Figures 5 shows the micro photos of the dried albumin particles in the case of the pneumatic spaying. The solid content in the source product is 28 % mass for all shown photos. The significant part of the particles is in a free state. Some particles are combined with each other. The quantity of combined particles is not significant. The shape of most of the particles is almost spherical.

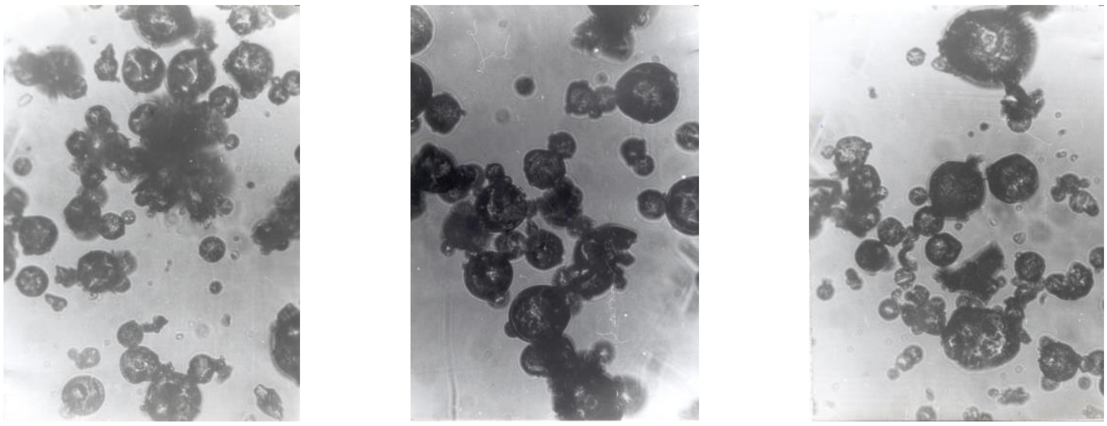

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Figure 4. Micro photos of the dried albumin particles in the case of the centrifugal spaying for the initial temperatures of the drying agent: a – 180 °C, b – 200 °C, c – 220 °C.

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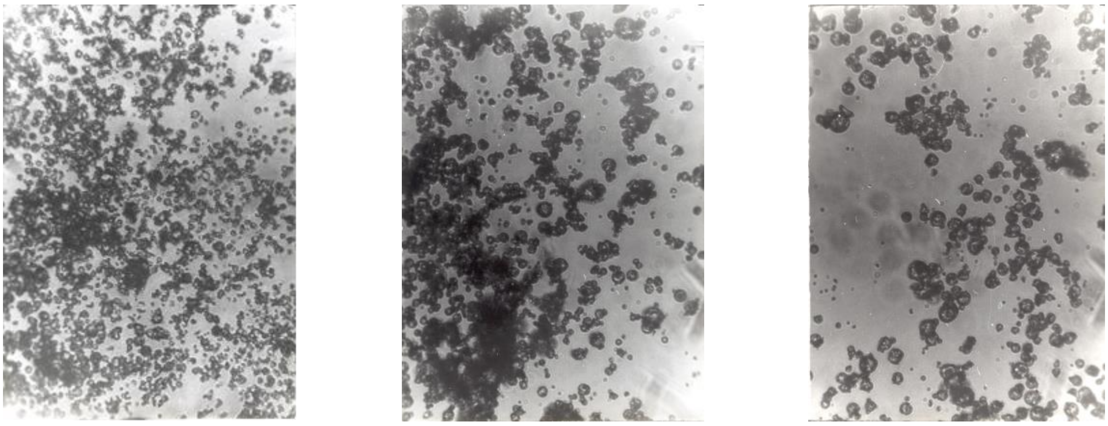

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Figure 5. Micro photos of the dried albumin particles in the case of the pneumatic spaying for the initial temperatures of the drying agent: a – 180 °C, b – 200 °C, c – 220 °C.

It is found that the spraying method does not influence on the shape of the bovine black albumin dried particles. The moisture influences on the dried product density significantly. The measured density of dried bovine black albumin is 1100 kg/m^3 with the 2 % moisture and 1200 kg/m^3 with the 3 % moisture.

4. Conclusion

We have obtained the experimental granulometric composition of the dried bovine black albumin. It was shown that the average particle size of the dried product decreases with the growth of the initial drying agent temperature for the spray drying using the mechanical centrifugal disk sprayer and the pneumatic nozzle sprayer. It was found that the average dried albumin particle size rises with the solid phase mass fraction in the source product.

We found that the average size of the dried albumin particles in the case of using the pneumatic sprayer is bigger than the average particles size in the case of using the centrifugal sprayer for the relatively small drying agent initial temperature and significantly less for drying agent initial temperature bigger than 200 °C.

It is shown that the significant part of the dried product particles is in a free state and shape of most of the particles is almost spherical. The spraying method does not influence on the shape of the bovine black albumin dried particles.

The measured density of dried bovine black albumin is 1100 kg/m^3 with the 2 % moisture and 1200 kg/m^3 with the 3 % moisture.

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